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PRODUCTION OF LENS SHEET

[*Renzu shiito no seizoh houhoh*]

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[*There are no amendments to this patent.*]

Specification

1. Title of the invention

Production of lens sheet

2. Claim of the invention

The production of a lens sheet consisting of coating a first ionizing radiation curing resin over the entire surface of a molding tool having a lens pattern, forming a resin bank of a second ionizing radiation curing resin on the above-mentioned first ionizing radiation curing resin coated over the above-mentioned molding tool, superimposing a base material uniformly on the resin bank of the above-mentioned second ionizing radiation curing resin and laminating the second ionizing radiation curing resin and the above-mentioned first ionizing radiation curing resin with a pressure roll, irradiating the above-mentioned ionizing radiation curing resins an ionizing radiation to cure them, and releasing the above-mentioned ionizing radiation cured resin product from the above-mentioned molding tool, wherein a lens sheet is produced, and the production process is characterized by the fact that the coating ratio of the above-mentioned first ionizing radiation curing resin in the area onto which the resin pool of the above-mentioned second ionizing radiation curing resin is formed is increased.

3. Detailed description of the invention

[Technical field of the invention]

The present invention pertains to a lens sheet production method wherein the lens member of a lens sheet is made of an ionization radiation curing resin that is used for transmission-type screens such as a fresnel lens sheet, prismatic lens sheet, or lenticular lens sheet, and the invention further pertains to a lens sheet production method that includes an improved resin coating process where an absence of migration of air bubbles in the lens member occurs.

[Prior art]

In the past, the above-mentioned lens sheet has been produced by methods such as press molding and casting. In the above-mentioned press molding method, a heat treatment, pressurization, and cooling cycle are used and productivity is low. In the casting method, a monomer is poured onto a molding tool and a polymerization reaction is carried out; thus, the production time is long; furthermore, many molding tools are required; thus, the production cost is high.

In order to solve the above-mentioned problems, a method wherein an ionizing radiation curing resin such as an ultraviolet curing resin or an electron beam curing resin is poured into the space between the molding tool and the base material, and an ionizing radiation such as ultraviolet or electron beam is applied and curing of the above-mentioned resin is achieved (photopolymerization process) is proposed.

[p. 2]

For example, in "Production of Screens for Video Projectors" disclosed in Japanese

Kokai [Unexamined] Patent Application No. Sho 62-33613, "a method wherein an ultraviolet curing resin is injected into a lens die at ambient pressure and covered with an ultraviolet transmitting sheet, and ultraviolet is applied to the ultraviolet curing resin filled between the ultraviolet transmitting sheet and molding tool through the above-mentioned ultraviolet-transmitting sheet, and subsequently the cured ultraviolet curing resin is released" is proposed.

[Problems to be solved by the invention]

However, the method proposed above is accompanied by the problems described below.

First, as a means of laminating the ultraviolet-transmitting sheet onto the ultraviolet curing resin injected into the die, "a method wherein the ultraviolet-transmitting base material is brought into contact with one side of the die filled with the ultraviolet curing resin by means of vacuum forceps, the other side covers the ultraviolet curing resin so that covering is done without trapping air bubbles" is proposed. However, in order to achieve the above-mentioned objective with vacuum forceps, the control device and driving device are complex, and the production cost is increased; furthermore, covering without trapping air bubbles at all is impossible.

Secondly, in the case of migration of air bubbles in the resin at the time of injection, "removal with a pipet, etc.", is proposed, but migration of air bubbles takes place at random and when it is necessary to detect migration of air bubbles and to remove air bubbles manually, productivity is reduced considerably and removal of air bubbles is uncertain.

Thirdly, defoaming of the resin is required before injection; thus, equipment and time are required, and, as a result, productivity is reduced and the production cost is increased.

When the above-mentioned air bubbles are allowed to remain in the lens member, the quality of the lens is reduced or quality of the image is reduced.

The purpose of the present invention is to eliminate the above-mentioned existing problems and to provide a lens sheet production method without air bubbles and without increased production cost.

[Means to solve the problem]

As a result of much research conducted by the present inventor, it was discovered the above-mentioned purpose can be achieved when an improved method of coating an ionizing radiation curing resin is used and the present invention was accomplished.

Fig. 1 is a diagram used for explanation of the concept of the lens sheet production method of the present invention.

The lens sheet production method of the present invention is a production method consisting of the coating of a first ionizing radiation curing resin 101, the coating of a second ionizing radiation curing resin 102, a uniform lamination process step 103, a resin curing process step 104, and a release process 105. The first resin coating process step 101 is a process step wherein the first ionizing radiation curing resin is coated over the entire surface of a molding tool having a lens pattern. The above-mentioned process is a process whereby wetting of the molding tool is made uniform, and at the same time, the coating ratio is stabilized, and defoaming in the process that follows is facilitated. In specific terms, the above-mentioned process can be achieved by means of the roll coating method, silk screen method, curtain coating method, gravure coating method, squeegee coating method, etc.

The second resin application process step 102 is a process step wherein a resin pool of the second ionizing radiation curing resin is formed at the end of the above-mentioned molding tool. The function of the second ionizing radiation curing resin used in the above-mentioned process

is to purge air bubbles trapped between the base material being laminated and the molding tool, and, at the same time, and to impart adhesion with the base material. As for the method used for formation of the resin pool of the second ionizing radiation curing resin, methods such as squeegee coating, flow coating, roll coating, and quantitative separation can be used.

Lamination process 103 is a process wherein an ionizing radiation transmitting base material is superimposed on the above-mentioned resin pool of the second ionizing radiation curing resin and lamination of the above-mentioned base material onto the above-mentioned second ionizing radiation curing resin is carried out as the second ionizing radiation curing resin is being evenly pressed by the pressure roll. In the above-mentioned process, air bubbles that migrate in the space between the molding tool and base component are purged and the thickness of the molded article is made uniform.

[p. 4]

Resin curing process 104 is a process wherein an ionizing radiation is applied to each of the above-mentioned ionizing radiation curing resins and curing is carried out. In the above-mentioned process, curing of the second ionizing radiation curing resin is achieved upon application of an ionizing radiation such as ultraviolet or an electron beam, and in this case, it is desirable when the light source is brought close as possible to the area being pressed by the roll. In this case, lifting between the molding tool and the base component and migration of air bubbles in the above-mentioned space can be prevented.

Release process step 105 is the process step wherein the cured ionizing radiation curing resin product is released from the above-mentioned molding tool.

For each of the above-mentioned ionizing radiation curing resins, ultraviolet curing resins

or electron beam curing resins can be used, and for example, one or a mixture of polymeric oligomers and monomers having an acryloyl group such as urethane acrylates, epoxy acrylates, polyester acrylates, polyether acrylates, and melamine acrylates, and polymeric oligomers and monomers having a polymeric vinyl group such as acrylic acids, acryl amides, acrylonitriles, and styrenes, can be mentioned; furthermore, additives such as sensitizing agents can be included, as needed.

For the above-mentioned ionizing radiation curing resins, it is desirable when a monomer or prepolymer having a polyfunctional group is used to improve general mechanical properties such as surface strength and hardness, and those with at least a bifunctional group can be used effectively.

Furthermore, dispersing agents can be included in the above-mentioned ionizing radiation curing resins. When a dispersing agent is used, coating properties can be improved and polymer shrinkage can be prevented; furthermore, [light] diffusing characteristics can be imparted. For the diffusing agent, glass, silica, alumina, insoluble plastics, talc, etc. can be used.

As for the ionizing radiation curing resin, for properties required for the first ionizing radiation curing resin, good die reproduction characteristics, defoaming characteristics, wetting of the die, and surface curability can be mentioned, and for properties required for the second ionizing radiation curing resin, good adhesion to the base material and good flow properties can be mentioned.

Furthermore, a resin with low viscosity adjusted to 200 centipoise or less is used for the first ionizing radiation curing resin, and a resin with a relatively high viscosity adjusted to 500~5000 centipoise is used for the second ionizing radiation curing resin. It is necessary for the

first ionizing radiation curing resin to have a low viscosity since the resin is coated over the entire surface without trapping air bubbles in the spaces formed by the fine lens pattern on the molding tool, and it is necessary for the second ionizing radiation curing resin to have a high viscosity since purging of air bubbles in the resin is performed. When the first ionizing radiation curing resin is formed as described above, defoaming at the boundary of the molding tool can be improved further.

When two layers of resin are used as described above, function of each resin with respect to the base material, the lens sheet, and the molded lens sheet can be effectively achieved; furthermore, when functions of the resin are divided between the two layers, the resins can be selected from a wide variety of resins.

The conditions for selection of the second ionizing radiation curing resin are explained below. In the case of a lens sheet, it is necessary for at least the refractive index of the two resins to be about the same. The reason is that the boundary between the first ionizing radiation curing resin and the second ionizing radiation curing resin layer is not necessarily flat; thus, when the refractive indexes of the two resins are significantly different, a uniform beam cannot be achieved.

As long as the above-mentioned relationship is satisfied, the same or different materials can be used for the above-mentioned first ionizing radiation curing resin and the second ionizing radiation curing resin. When different resins are used, resins having similar refractive indexes are used taking the properties of each resin into consideration, and for example, a urethane acrylate resin having good die reproduction characteristics and surface curability can be used as the first ionizing radiation curing resin, and an epoxy acrylate resin having good adhesion with

the base material can be used for the second ionizing radiation curing resin. Furthermore, an adjustment can be made for properties such as wetting of the die, flow properties, and viscosity using methods such as changing the resin temperature during the course of the resin processing of the first ionizing radiation curing resin and second ionizing radiation curing resin, including additives (defoaming agents, leveling agents, etc.), or changing the mixing ratio of the monomers or oligomers in the first ionizing radiation curing resin and second ionizing radiation curing resin. In the case when an adjustment is made with a solvent, it is desirable when the solvent used is evaporated after coating so as to prevent shrinkage of the resin or deterioration of the solvent.

[p. 5]

Furthermore, a dispersing agent can be included in one or both of the above-mentioned first ionizing radiation curing resin and second ionizing radiation curing resin.

For the base material, a sheet or film having good solvent resistance, high transparency, and high ionizing radiation transmissivity can be used effectively. Furthermore, it is desirable when a resin having adequate adhesion with the ionizing radiation curing resin and high mechanical strength is used. For the above-mentioned base material, a primer layer having good adhesion made of materials such as a vinyl chloride/vinyl acetate copolymer or urethane may be deposited.

In the following, the lens sheet production method of the present invention is explained in further detail with the focus on the resin coating process.

Fig. 2 and Fig. 3 are diagrams used for explanation of the resin coating process in the lens sheet production method of the present invention.

In the present invention, the coating ratio of the above-mentioned first ionizing radiation curing resin in the area where the resin pool of the second ionizing radiation curing resin is to be formed is high, and in specific terms, coating is performed so that the coating ratio is greater than the depth of the grooves of the molding tool.

When the coating ratio of the first ionizing radiation curing resin is insufficient and [the thickness] is less than the height of the peaks of the lens pattern of the molding tool 4 (Fig. 2(a)), a gaseous phase 7 exists between the first ionizing radiation curing resin and second ionizing radiation curing resin when the second ionizing radiation curing resin is applied by dispenser 6 (Fig. 2(b)); thus, an adequate purging cannot be achieved when defoaming is performed during the course of the resin coating process 102 and in many cases, fine air bubbles 7a remain in the lens member after coating (Fig. 2(c)).

When an adjustment is made for the coating ratio of the first ionizing radiation curing resin in the area onto which the second ionizing radiation curing resin is to be applied so that said resin coating has a thickness greater than the height of the peaks of the lens pattern of the molding tool as in the case of the method of the present invention (Fig. 3(a)), the gaseous phase between the first ionizing radiation curing resin and second ionizing radiation curing resin is eliminated when second ionizing radiation curing resin is applied by means of dispenser 6 (Fig. 3(b)), and air bubbles do not remain in the lens member after coating (Fig. 3(c)).

When the maximum height of the peaks of the molding tool is approximately 150 μm, the above-mentioned coating of the first ionizing radiation curing resin can be increased to a thickness of 30~70 μm greater than the height of the above-mentioned peaks.

In this case, in the first resin coating process step 101, at the time when the first ionizing

radiation curing resin is coated over the entire surface of the molding tool, and when the coating thickness is greater than the height of the peaks of the molding tool over the entire surface of the molding tool, and when the viscosity of the first ionizing radiation curing resin high, the wettability of the molding tool by the ionizing radiation curing resin is poor, and the viscosity of the above-mentioned resin is high, a thick coating with an absence of air bubbles is difficult to achieve.

Furthermore, when a solvent is added to the lens sheet and the viscosity is reduced to 30 centipoise or below in an attempt to increase the wettability of the molding tool and the lens sheet and to produce a thick coating with an absence of air bubbles, the solvent added is likely to have an adverse effect on the properties when it remains in the molding; thus, it is necessary to evaporate the solvent. Thus, the solvent removal process requires time and the productivity is reduced.

Furthermore, when a thick coating of the lens sheet is applied over the entire area, the coating ratio is increased and the amount of resin used increased; furthermore, removal of excess resin left behind is required; thus, production cost is increased.

The lens sheet production method of the present invention can be used effectively for production of fresnel lens sheets, prismatic lens sheets, lenticular lens sheets, etc., and the invention can be used effectively for other items having a fine pattern on the surface such as optical cards, optical disks, and holograms.

[Application Examples]

In the following, the present invention is explained in further detail with application examples.

Fig. 4~Fig. 8 are drawings that show application examples of the lens sheet production method of the present invention.

In each figure, 1 is the first UV curing resin, 2 is second UV curing resin, 3 is the base material, 4 is the molding tool, 5 is the pressure roll, and 6 is the UV light source.

First, as shown in Fig. 4, the first UV curing resin 1, applied to molding tool 4 having a Fresnel lens pattern with a length and width of 1 m each and pitch of 0.1 mm, is a urethane acrylate based resin with refractive index adjusted to 1.49 and viscosity to 100 centipoise, and it is coated onto the molding tool so as to form a thickness of approximately 40 μm from the bottom of the molding tool (Fig. 4(a) t_1) [*sic*], and an additional thickness of an approximately 50 μm was further applied in area 1A outlined by the dotted line (Fig. 4(a) t_2) [*sic*].

In order to achieve the above-mentioned coating, as shown in Fig. 5(a), a uniform coating is performed for the entire surface of the molding tool so that a thickness of 50 μm from the peak of the molding tool can be achieved using roll coater 8, as shown in Fig. 5(b) and (c), [the resin] was then scraped away in areas other than the above-mentioned area surrounded by dotted lines 1A using squeegee 9 so as to form the above-mentioned thickness. In this case, a timing sensor, etc. is used for the top and the bottom of the squeegee, and the operation is performed at a height of 5~10 cm below the top of the molding tool.

Subsequently, as shown in Fig. 6, the second UV curing resin 2 was applied to the first UV curing resin in the above-mentioned area surrounded by dotted lines 1A using the flow coating method so as to form a resin pool of 0.5 g/cm^2. For the above-mentioned second UV curing resin, an epoxy acrylate based resin with the refractive index adjusted to 1.49 and

viscosity to 1500 centipoise was used.

After forming the resin pool as explained above, a transparent acrylic sheet having a thickness of 3.0 mm and coated with a vinyl chloride/vinyl acetate copolymer base primer was laminated as base material 3, and pressure rolls 5,5 were applied at a rate of 50 cm/min as shown in Fig. 7. In this case, air bubbles between molding tool 1 and base material 3 are purged in the region indicated by A in the fig. In this case, 160 W/cm of ultraviolet (UV) is applied from the base side by means of ultraviolet light source 6, and curing of the first UV curing resin and second UV curing resin was achieved.

And finally, release of the molding tool was performed as shown in Fig. 8 and a fresnel lens sheet was produced. In the above-mentioned fresnel lens sheet, the lens member side has a structure comprising the first UV curing resin and the base material side has a structure comprising the second UV curing resin and the base material 3 is further laminated. In this case, air bubbles were absent in the region where the second UV curing resin was applied.

Fig. 9 and Fig. 10 show different application examples of the lens sheet production method of the present invention.

In the examples, in order to eliminate molding defects at the edges of the lens sheet, the second UV curing resin is coated in the form of the letter U as shown.

In this case also, uniform coating with the first UV curing resin 1 is carried out, and subsequently, the resin is scraped away by squeegee 9 with a narrow width with the exception of the U-shaped region, and the thickness of the area of the first UV curing resin surrounded by dotted line shown in 1B alone is greater.

Furthermore, the second UV curing resin 2 was further coated to form a U-shape. A resin

pool of the second UV curing resin of 70 g was formed at the left end and resin pools of 20 g each were formed on both sides and production of a lens sheet was carried out as in the case of Application Example 1 shown in Fig. 1.

Migration of air bubbles was absent in the area where the second UV curing resin was applied in this case as well.

[Effect of the invention]

As explained in detail, according to the method of the present invention, the coating ratio of the first ionizing radiation curing resin in the area where the second ionizing radiation curing resin is to be applied is increased; thus, migration of air bubbles is absent at the time of application of the second ionizing radiation curing resin and production of a lens sheet with an absence of air bubbles is made possible.

4. Brief description of the figures

Fig. 1 is a diagram used for explanation of the lens sheet production method of the present invention.

Fig. 2 and Fig. 3 are diagrams used for explanation of the resin coating process in the lens sheet production method of the present invention.

[p. 6]

Fig. 4~Fig. 8 are drawings that show application examples of the lens sheet production based on the method of the present invention.

Fig. 9 and Fig. 10 are drawings that show a different application of lens sheet production

based on the method of the present invention.

1: First UV curing resin

2: Second UV curing resin

3: Base material

4: Molding tool

5: Roll

6: UV light source

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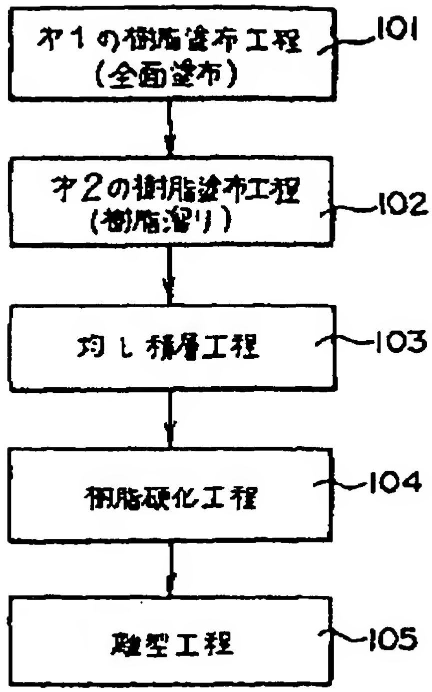
Fig. 1



101: First ionizing radiation curing resin coating process (entire surface coating)

102: Second ionizing radiation curing resin coating process (resin bank)

103: Uniform lamination process

104: Resin curing process

105: Release process

Fig. 2

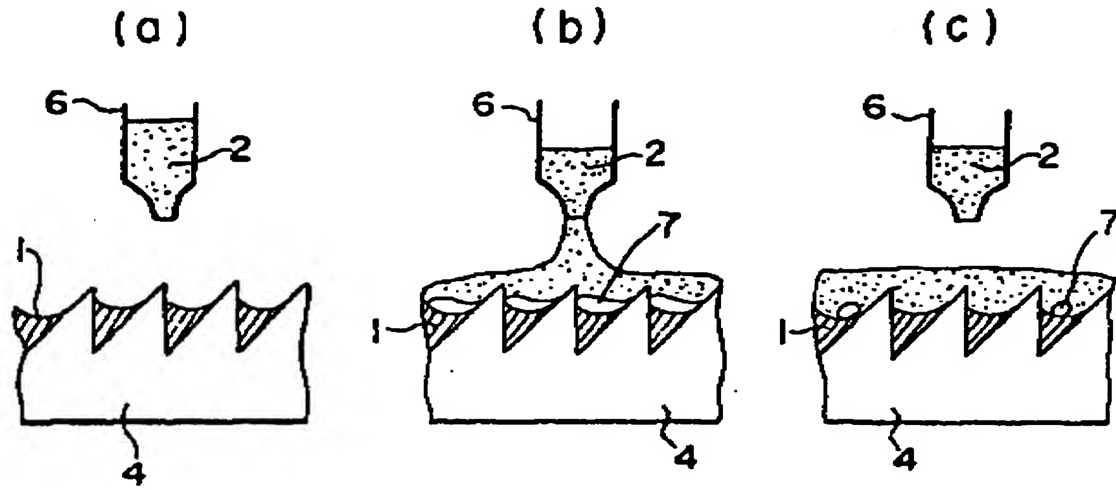


Fig. 3

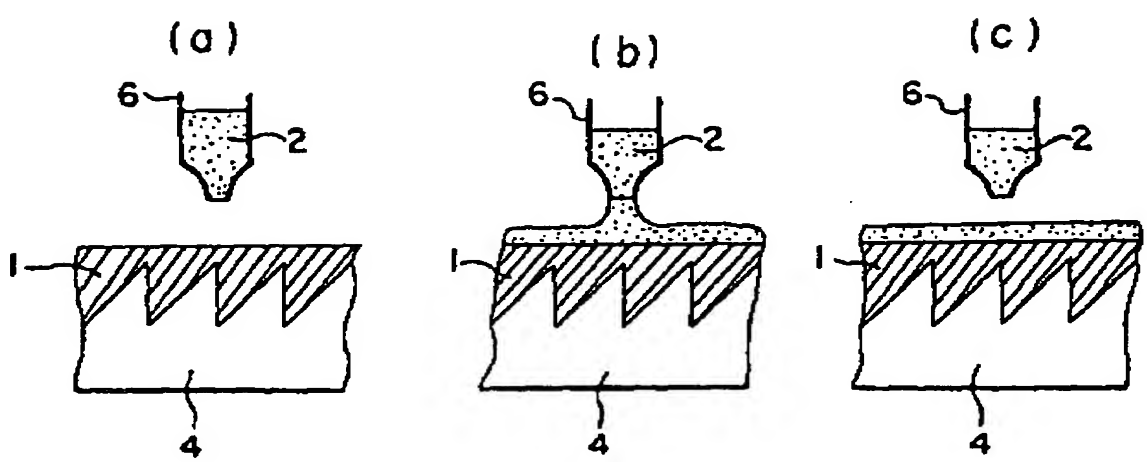
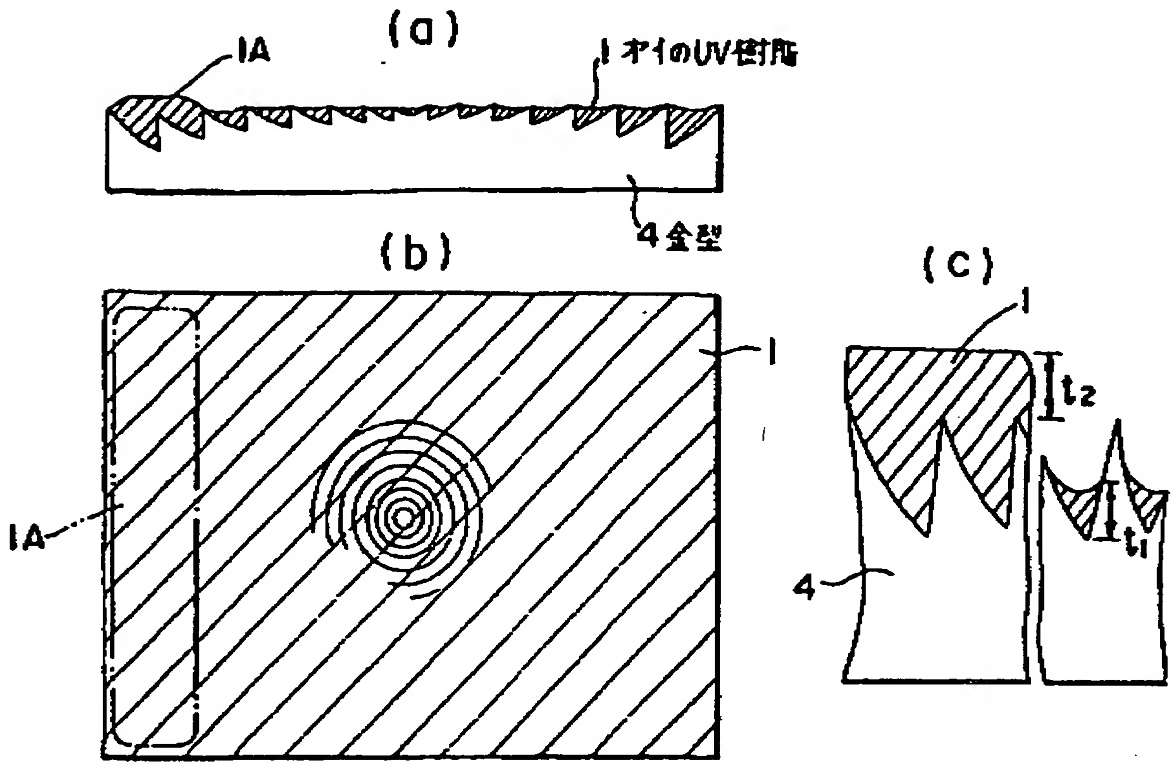


Fig. 4



1: First UV curing resin

4: Molding tool

Fig. 5

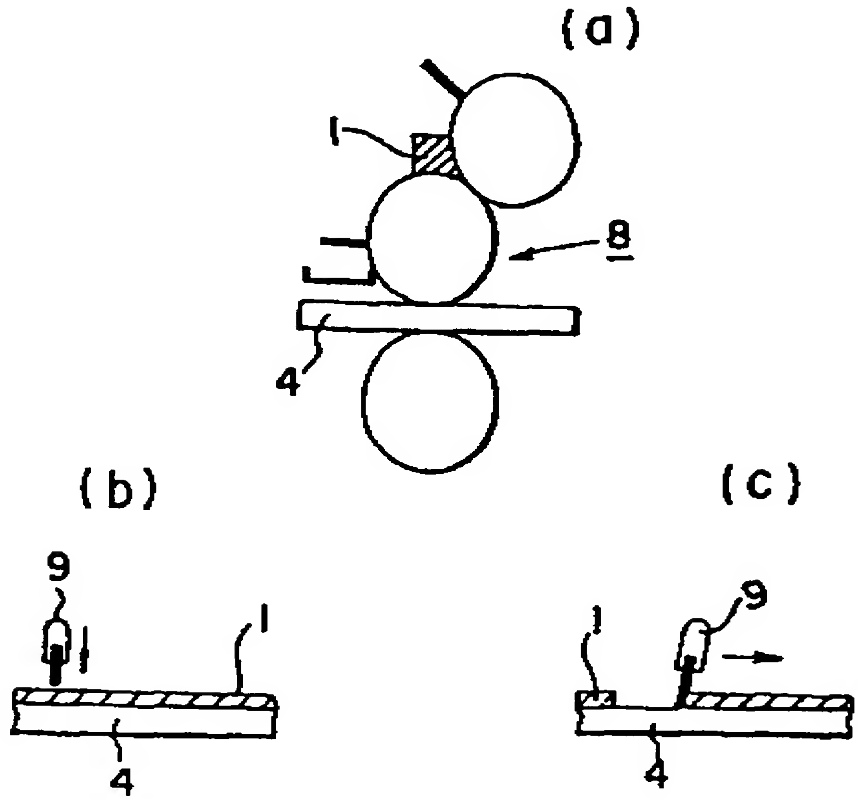
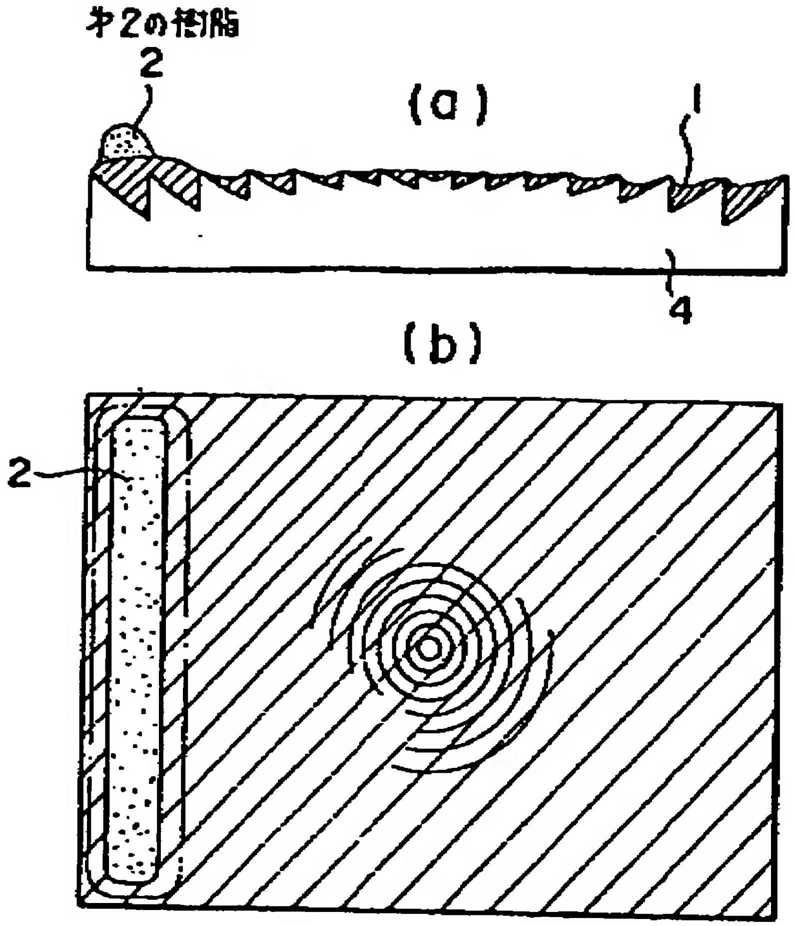
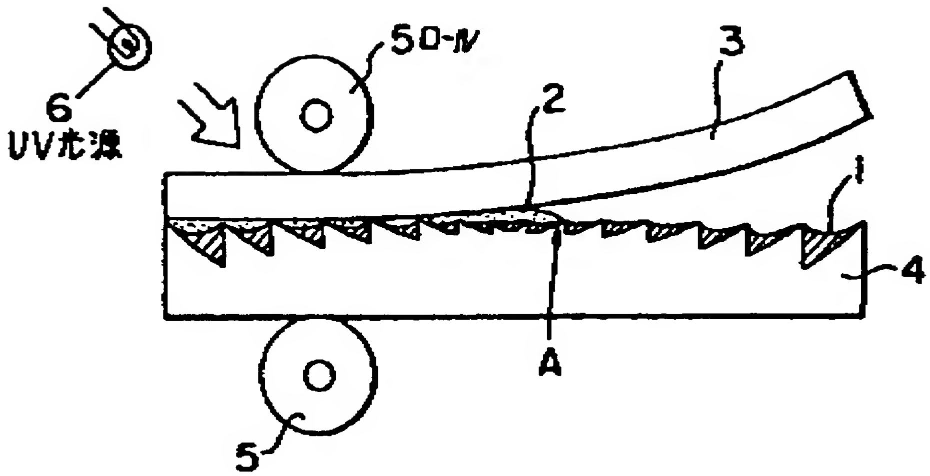


Fig. 6



2: Second UV curing resin

Fig. 7



5: Roll

6: UV light source

Fig. 8

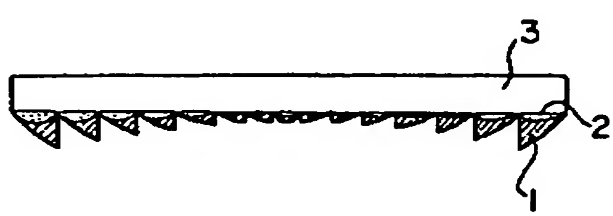


Fig. 9

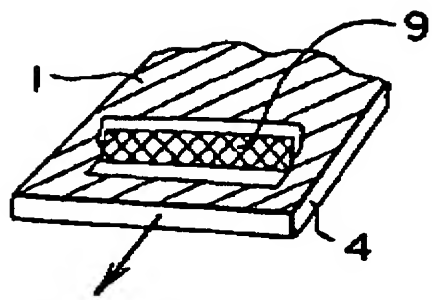


Fig. 10